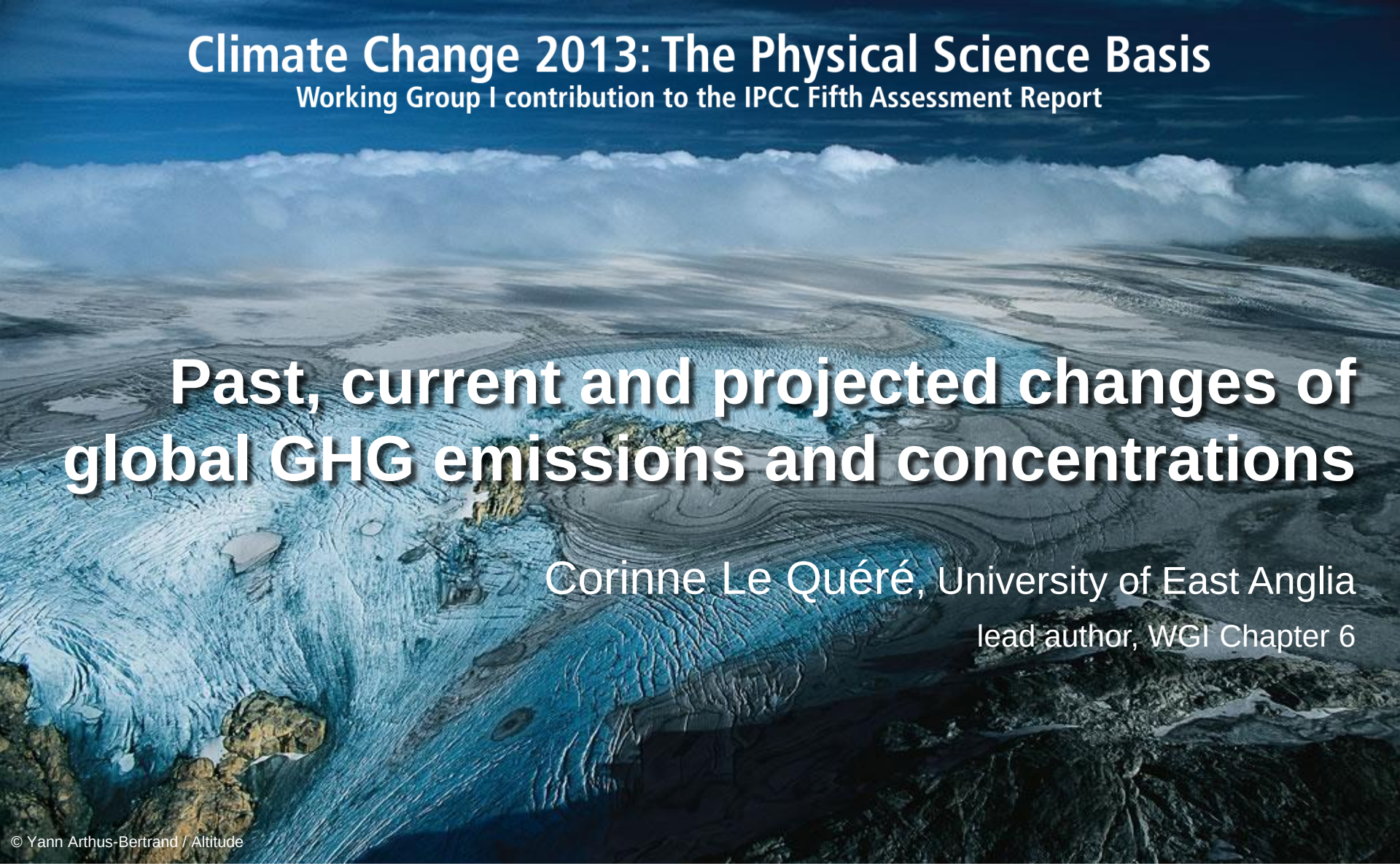


Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Past, current and projected changes of global GHG emissions and concentrations

Corinne Le Quéré, University of East Anglia

lead author, WGI Chapter 6

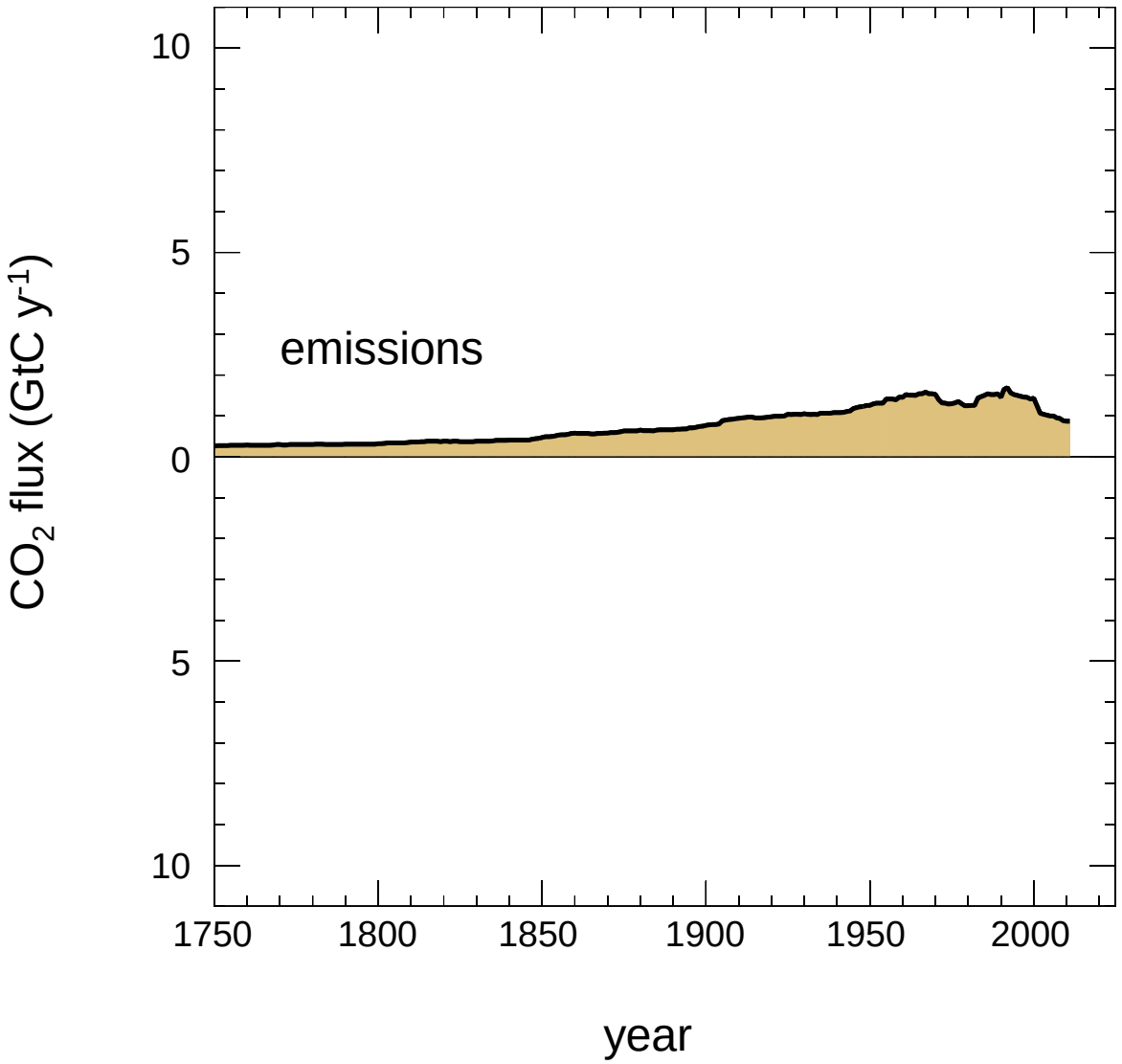
Change in greenhouse gas concentrations

	1750		2011
CO_2	278 ppm	→	390.5 ppm (+40%)
CH_4	722 ppb	→	1803 ppb (+150%)
N_2O	271 ppb	→	324.2 ppb (+20%)

The largest contribution to total radiative forcing since 1750 is from CO_2

The increase in CO_2 is responsible for most of the increase in radiative forcing since AR4

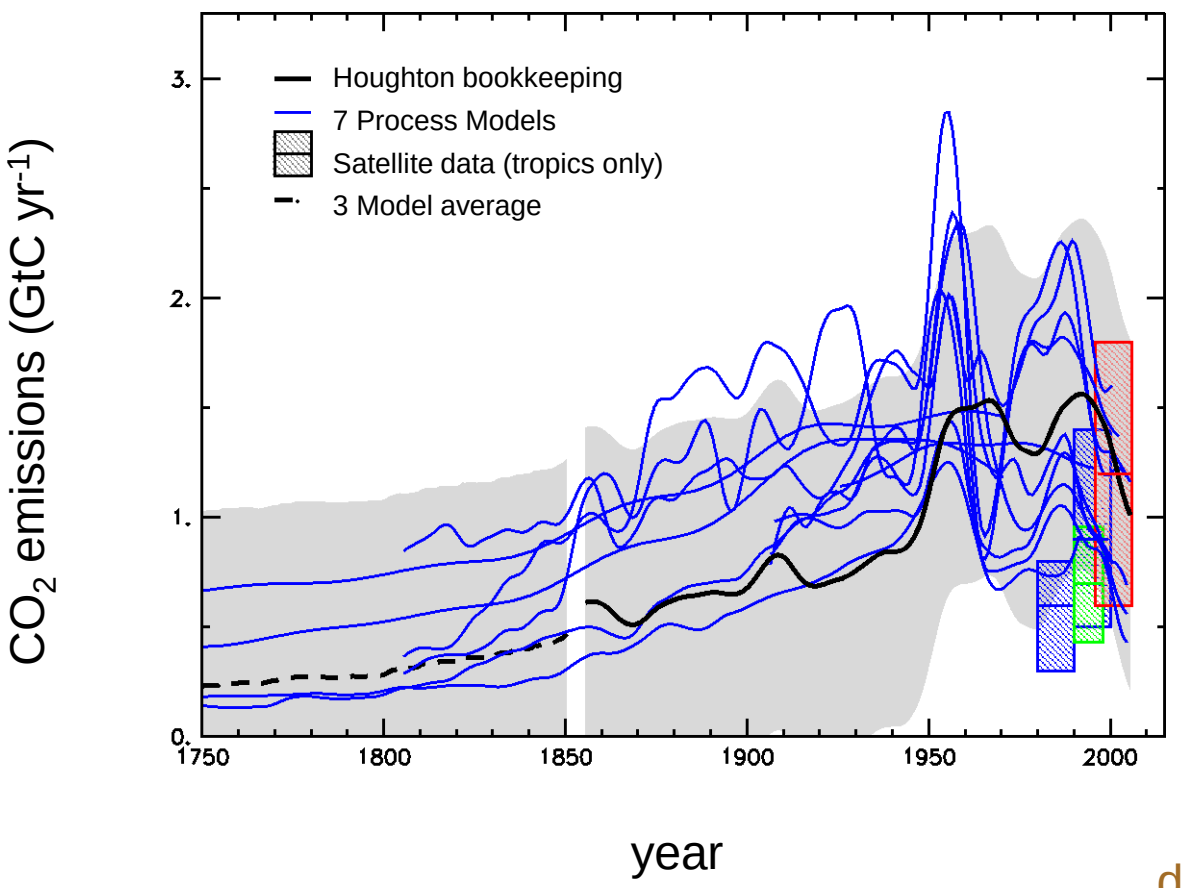
CO_2 emissions

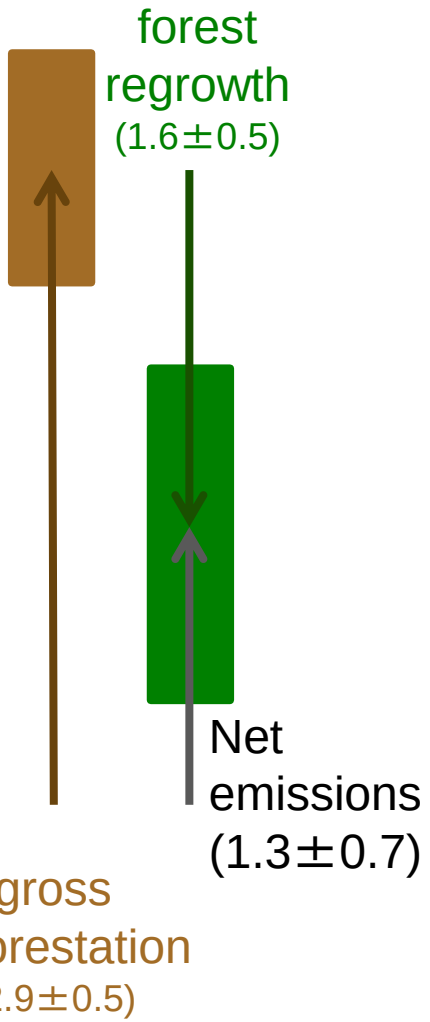


land-use change
uncertainty of ±0.8

source: Chapter 6; Houghton et al. Biogeosciences 2013

CO_2 emissions from land-use change





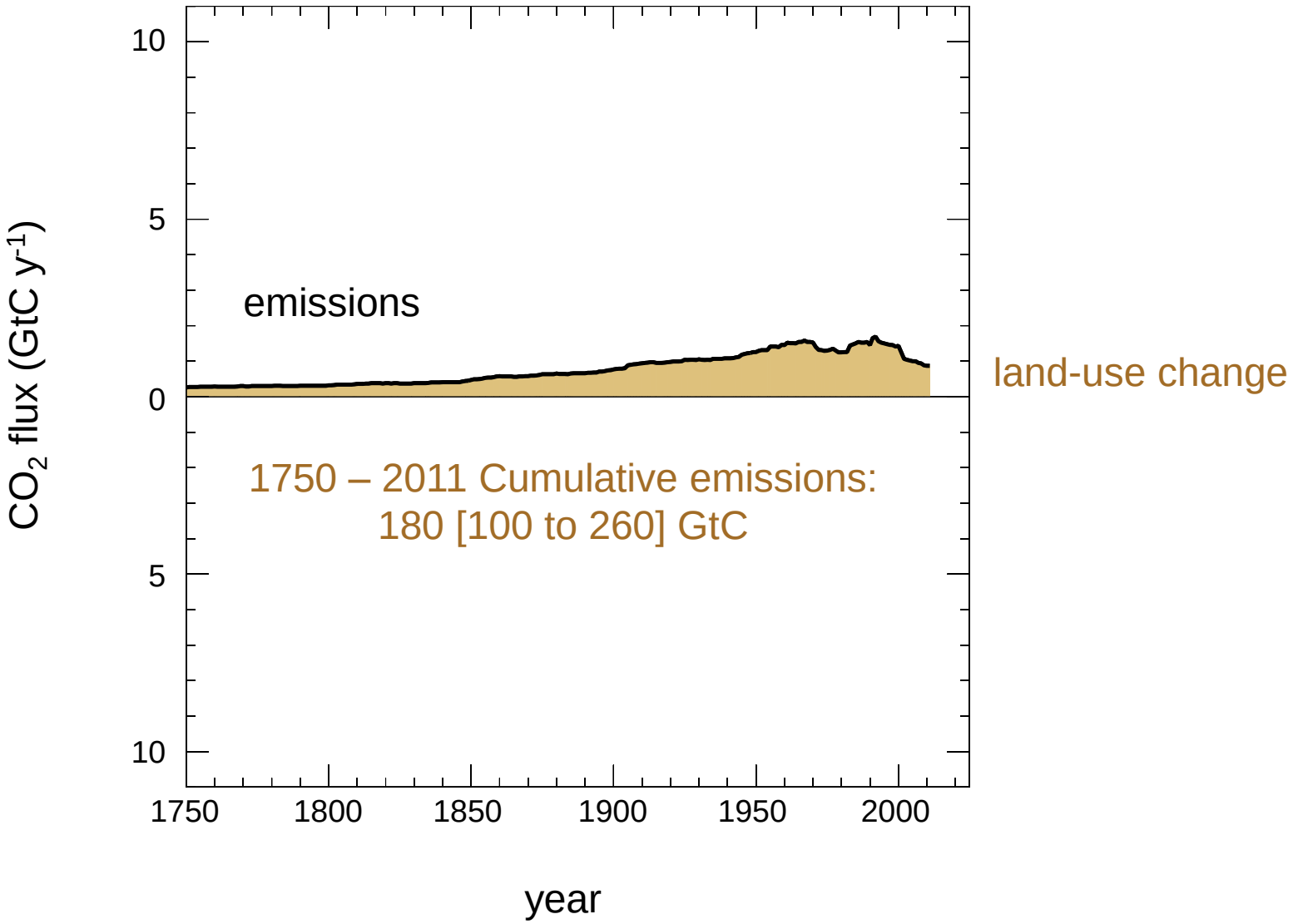
Land-use change emissions have large uncertainties

Land-use change emissions can be negative

Pan et al. (2011)
1990 – 2007

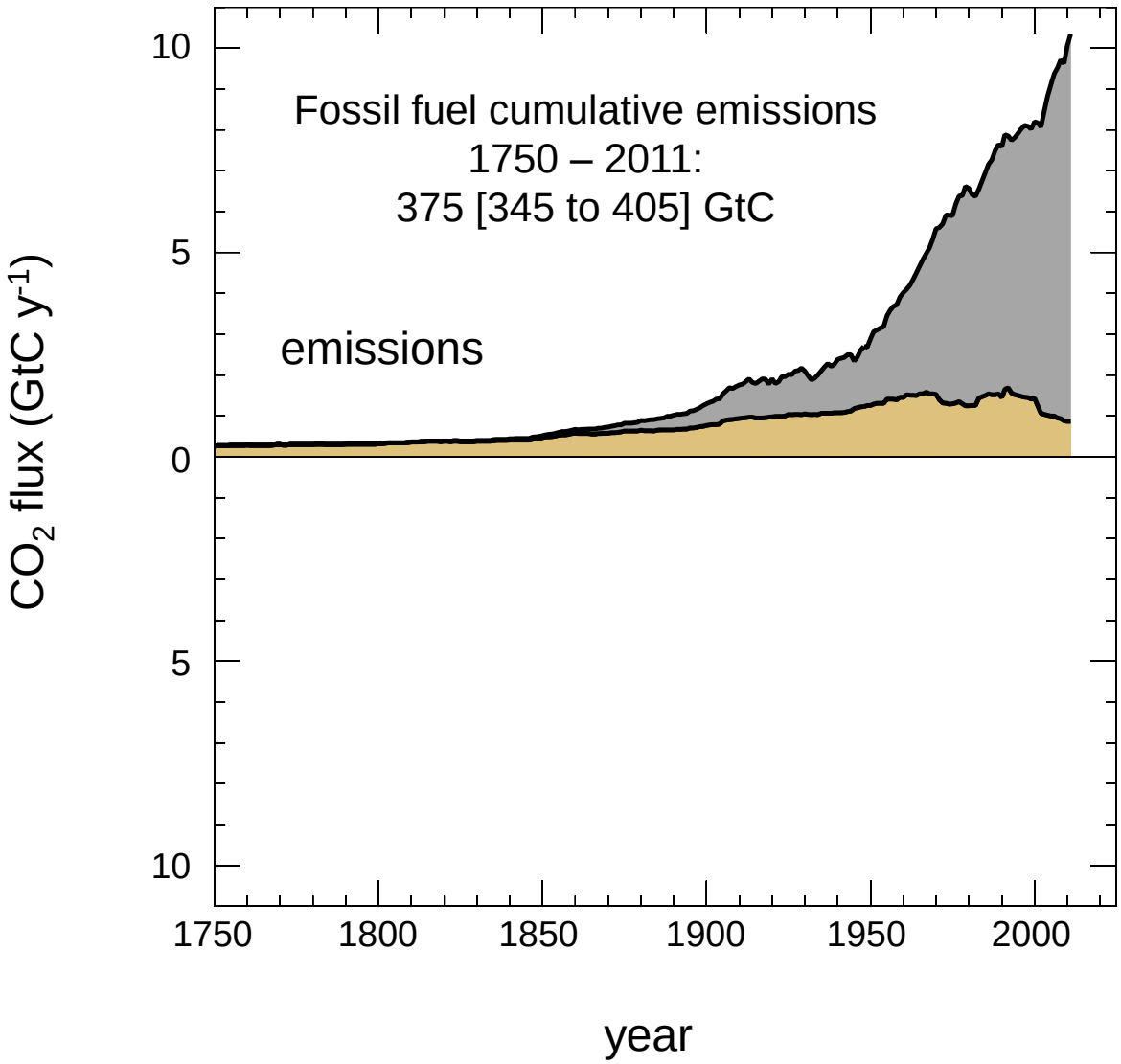
source: Chapter 6

CO_2 emissions



source: Chapter 6; Houghton et al. 2013

CO_2 emissions

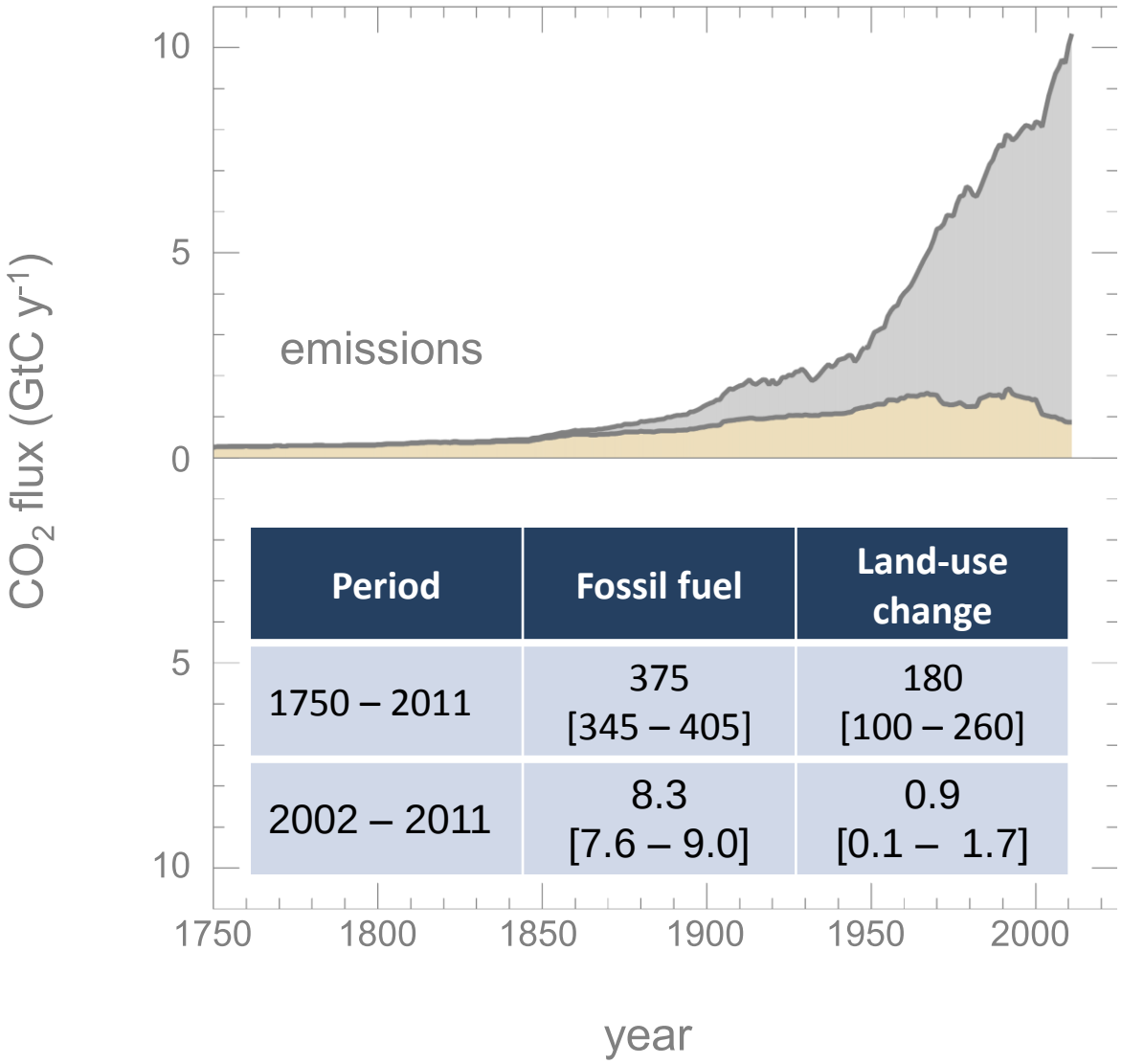


fossil fuel & cement
uncertainty of ±8%

land-use change

source: Chapter 6; CDIAC emissions

CO_2 emissions



Period	Fossil fuel	Land-use change
1750 – 2011	375 [345 – 405]	180 [100 – 260]
2002 – 2011	8.3 [7.6 – 9.0]	0.9 [0.1 – 1.7]

fossil fuel & cement

land-use change

Fossil / Land-use

70% / 30%

90% / 10%

source: Chapter 6; CDIAC emissions

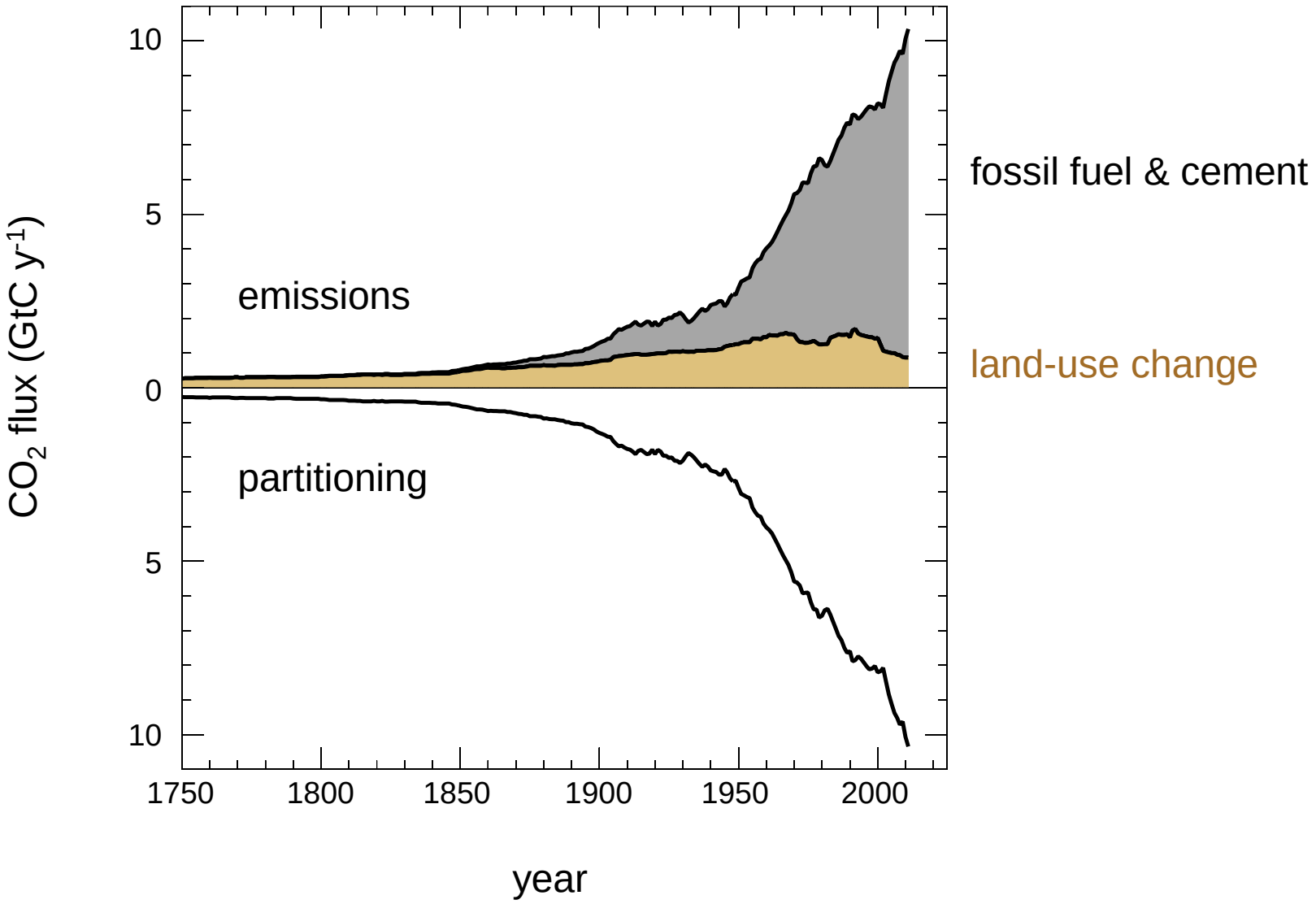
Cumulative historical emissions

Historical emissions				
Period	GtC		$GtCO_2$	
	Mean	Range	Mean	Range
1750 – 2011	555	470 to 640	2035	1725 to 2345
1870 – 2011	515	445 to 585	1890	1630 to 2150

Cumulative historical emissions known to about ±85 GtC
mainly due to uncertainties in land-use emissions

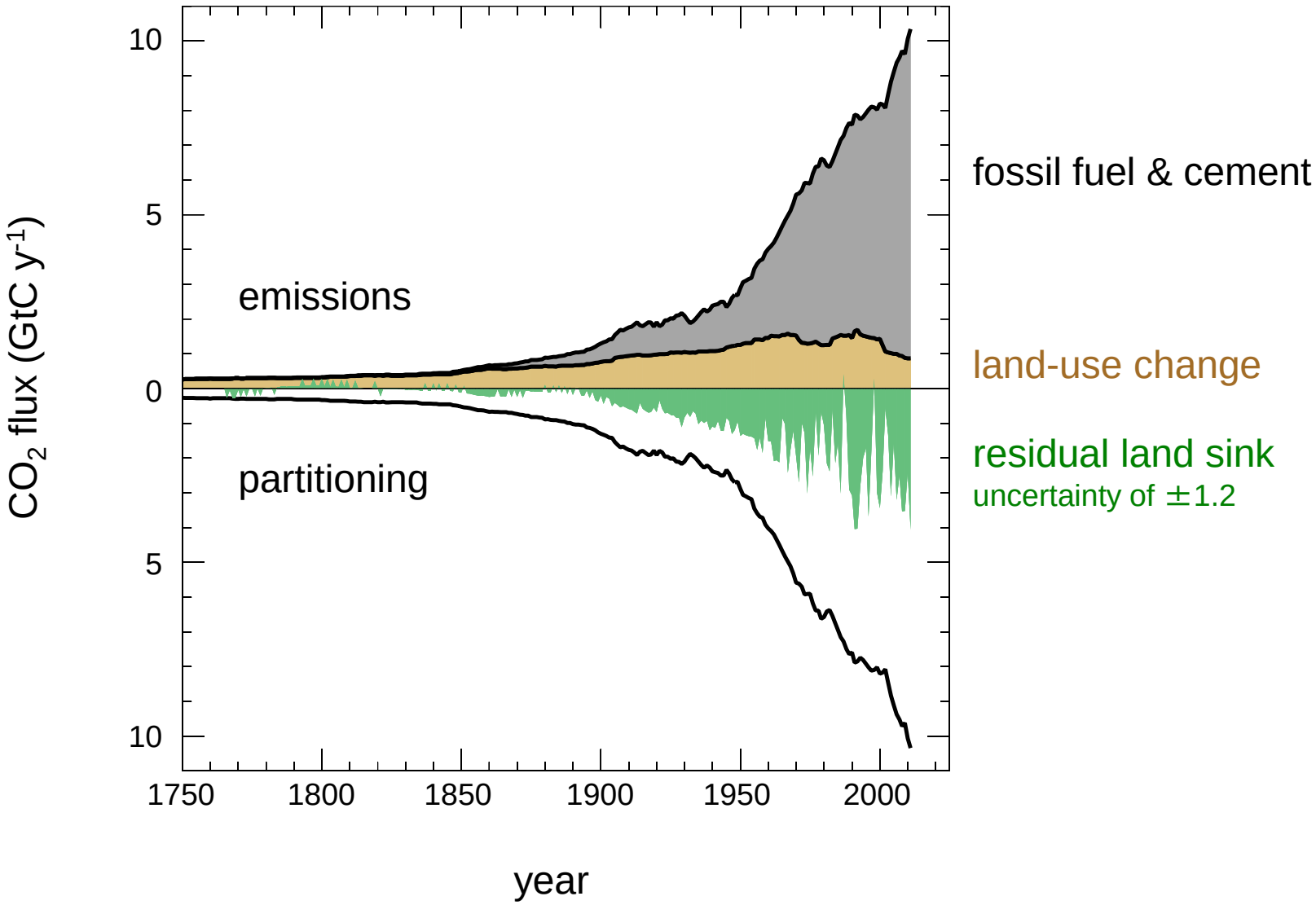
source: IPCC AR5

Carbon balance in the environment



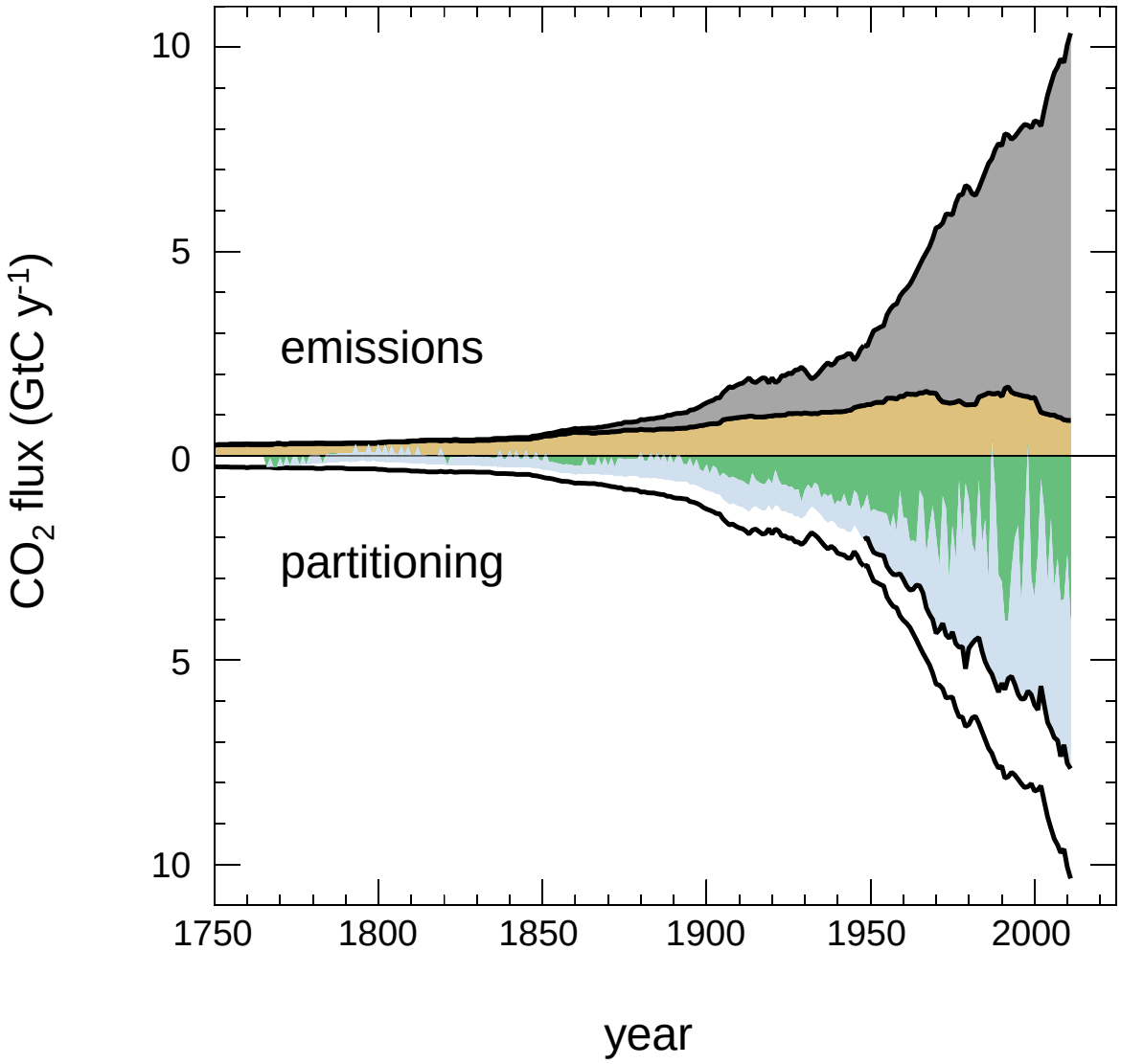
source: Chapter 6; CDIAC/Houghton emissions

Carbon balance in the environment



source: Chapter 6

Carbon balance in the environment

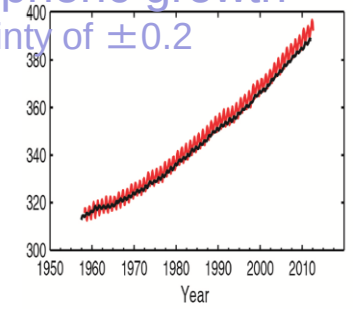


fossil fuel & cement

land-use change

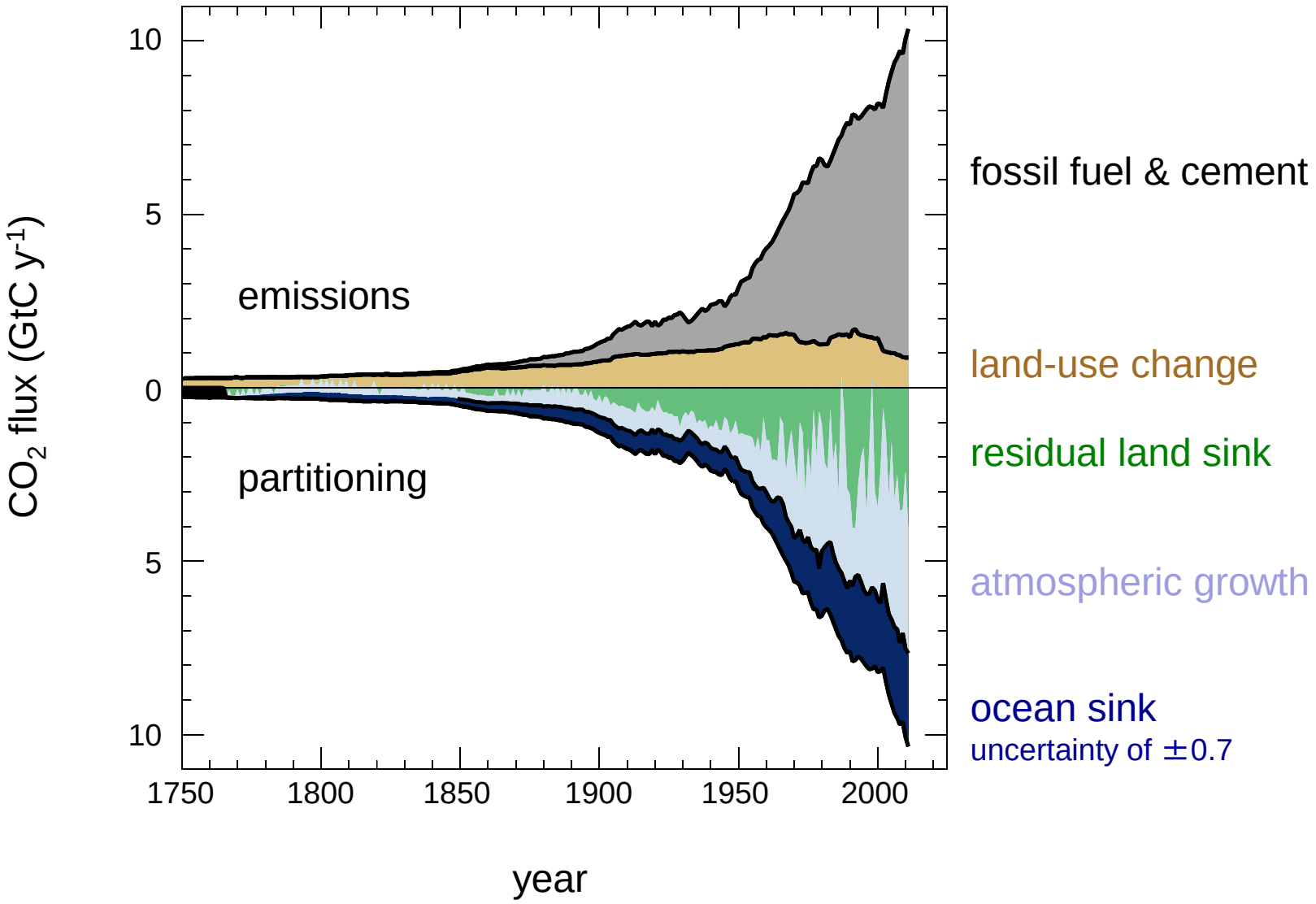
residual land sink

atmospheric growth
uncertainty of ±0.2



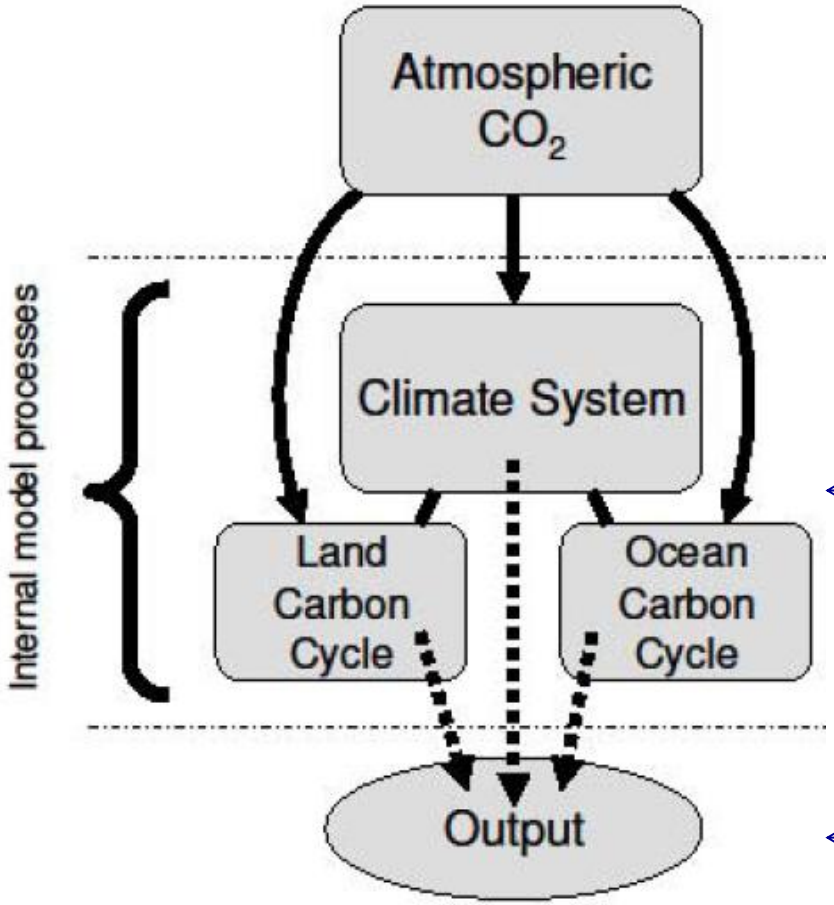
source: Chapter 6; NOAA/ESRL & Scripps Institute of Oceanography

Carbon balance in the environment



source: Chapter 6

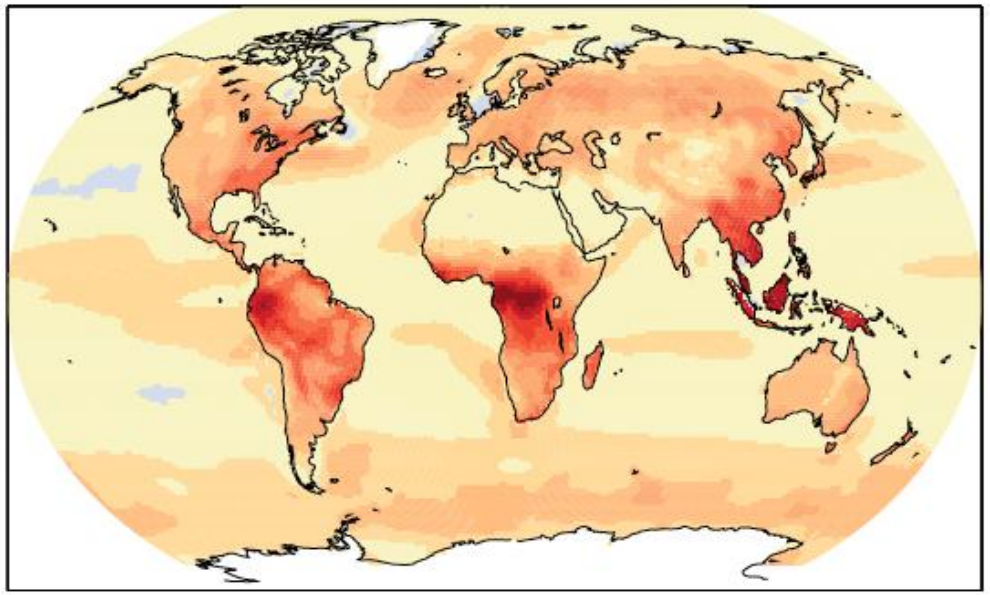
15 Earth System Models (ESMs) were used to compute emissions compatible with the RCP scenarios



ESMs represent climate and carbon cycle processes and how they interact

ESMs provide compatible emissions, which include the uncertainty in carbon – climate feedbacks

ESM response to increasing atmospheric CO_2 only



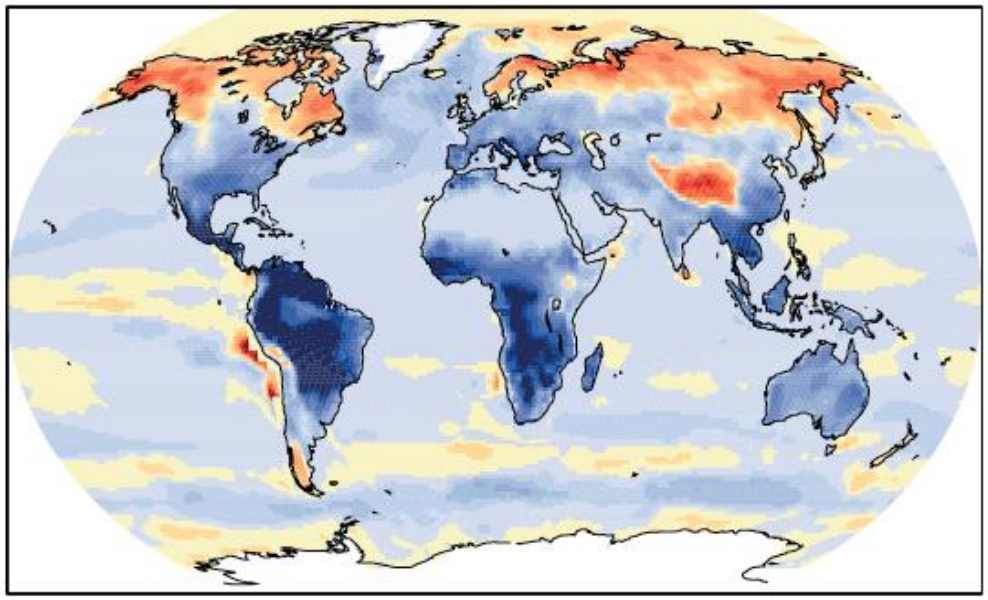
decreasing sink

increasing sink

Land and ocean CO_2 sinks continue in response to increasing CO_2 alone

source: Chapter 6

ESM response to climate change only



decreasing sink

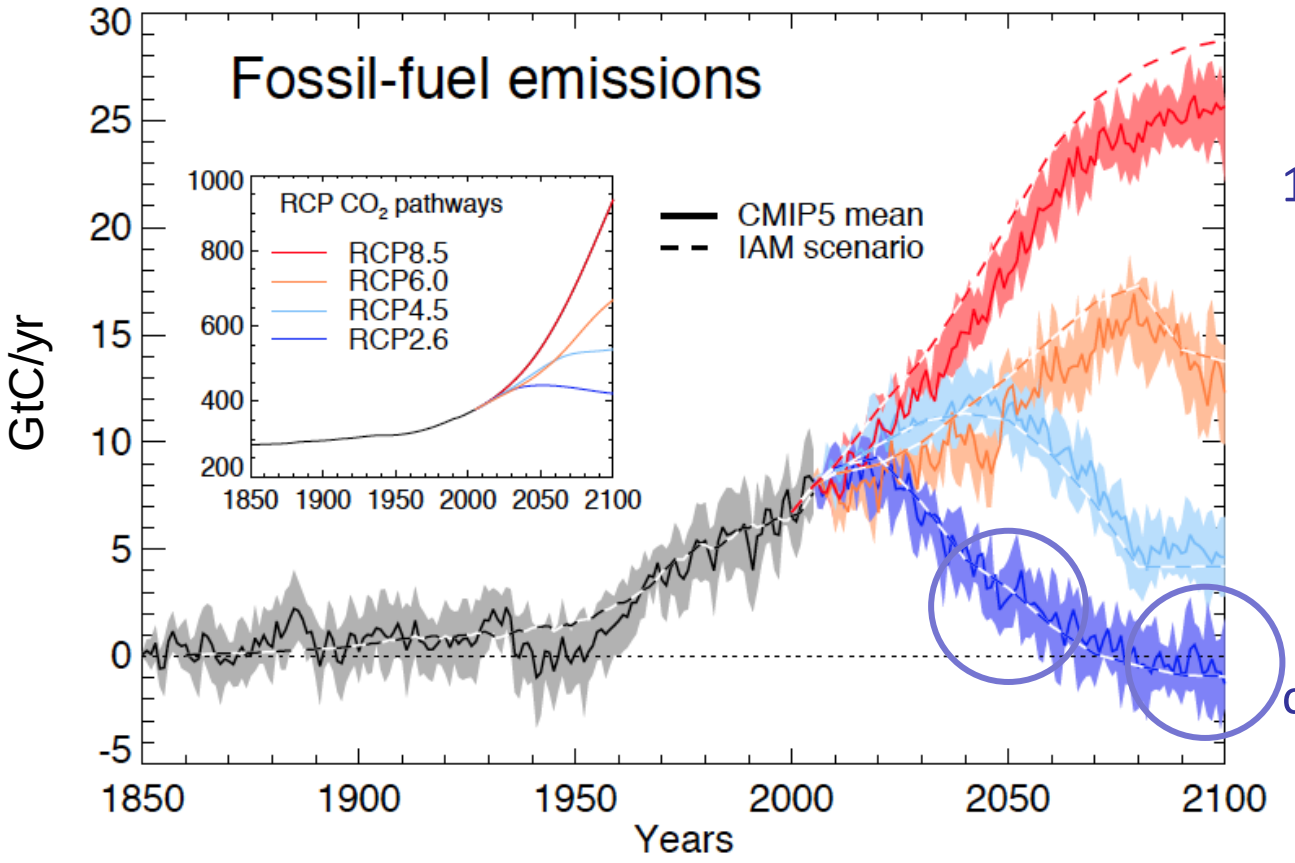
increasing sink

Climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO_2 in the atmosphere (*high confidence*)

models do not include the release of permafrost C

source: Chapter 6

Emissions compatible with the RCP scenarios from ESMs



By 2050, emissions in RCP2.6 are smaller than 1990 emissions by 50% on average (range 14-96%)

By 2100, about half the models have emissions below zero in RCP2.6

Uncertainties in carbon cycle feedback included in the uncertainties in emissions

source: Chapter 6

Compatible emissions for all RCPs compared to historical

Historical emissions				
Period	GtC		$GtCO_2$	
	Mean	Range	Mean	Range
1750 – 2011	555	470 to 640	2035	1725 to 2345
1870 – 2011	515	445 to 585	1890	1630 to 2150

Scenario	Cumulative CO_2 Emissions 2012 to 2100[a]			
	GtC		$GtCO_2$	
	Mean	Range	Mean	Range
RCP2.6	270	140 to 410	990	510 to 1505
RCP4.5	780	595 to 1005	2860	2180 to 3690
RCP6.0	1060	840 to 1250	3885	3080 to 4585
RCP8.5	1685	1415 to 1910	6180	5185 to 7005

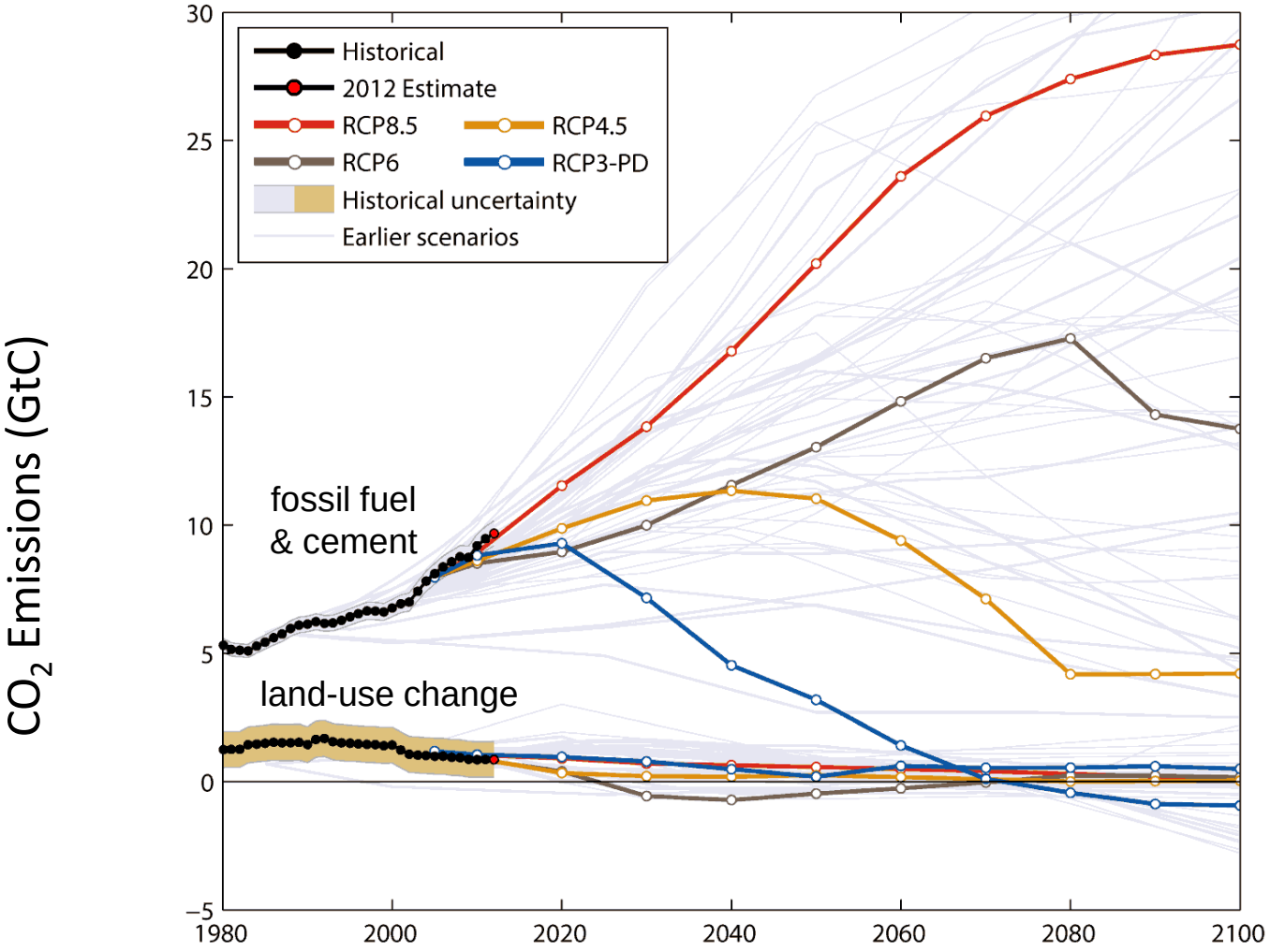
Historical emissions exceed emissions in RCP2.6

Range in compatible emissions for a given scenario is large

Total CO_2 emissions in 2011 about 10 GtC and growing

source: IPCC AR5

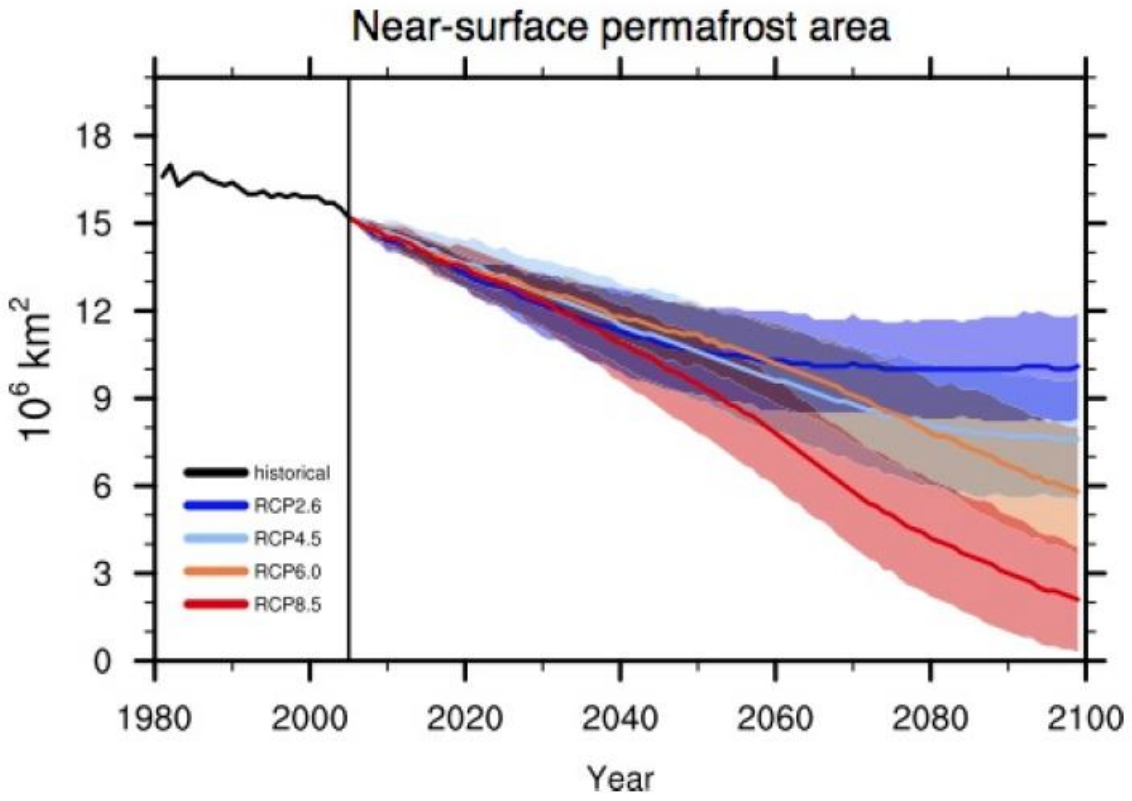
Historical CO_2 emissions compared to future pathways



Updated from Peters et al., Nature Climate Change 2013; CDIAC Data; Global Carbon Project 2012

Side Event here November 20, 3pm for 2012 update and 2013 projection

CO_2 – climate feedbacks not in ESMs



Frozen permafrost

C stock in permafrost:
1700 GtC

C released to the atmosphere from permafrost thawing:

50 – 250 GtC in RCP8.5, or 3-15 % of compatible emissions
(low confidence)

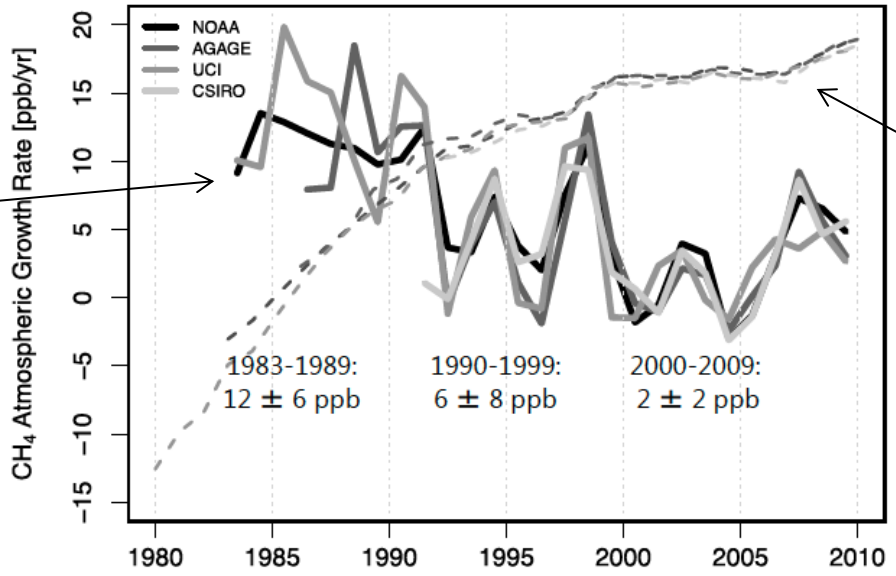
Other feedbacks not included in models:

- Wetlands CH_4 increased emissions under warmer climate (agreement in direction; amplitude less than permafrost effect in models)
- Large CH_4 release to the atmosphere from marine hydrates *unlikely* this century

source: Chapters 12 & 6

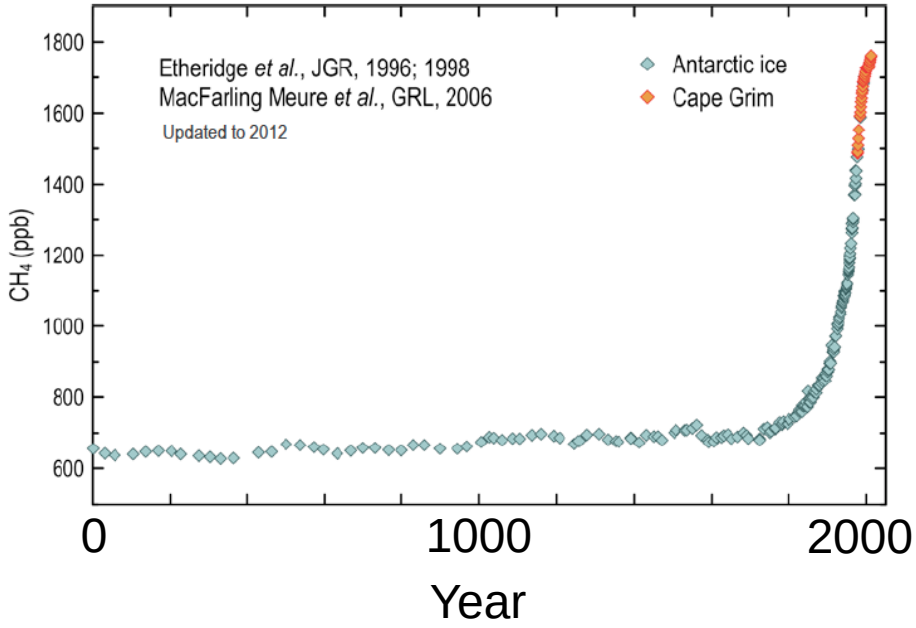
Renewed growth in atmospheric CH_4 concentration after 2006

CH_4 growth rate (ppb/yr)



1800 ppb

CH_4 concentration



1800 ppb

CH_4 concentration

Recent rise probably caused by rise in natural wetlands and by fossil fuel emissions, but their relative contribution is uncertain

Kirscke et al Nature Geosciences 2013

Summary:

- The largest contribution to total radiative forcing is caused by the increase in atmospheric CO_2
- CO_2 emissions from fossil fuel & cement now account for about 90% of total CO_2 emissions
- Climate change will affect carbon cycle processes in a way that will exacerbate the CO_2 increase in the atmosphere
- Cumulative emissions compatible with RCP2.6 are less than historical emissions
- WGIII Chapter 5 will assess emissions by sectors and countries

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Further Information

www.climatechange2013.org

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP